ONR's Advanced Gun Barrel Technologies Program

Michael Hermanson
United Defense L.P.
Minneapolis, MN

(763)572-4759
michael.hermanson@udlp.com

AGBT Background

- A five-year program funded by the Office of Naval Research as part of Time Critical Strike Future Naval Capabilities (FNC)

- Program supported by PMS500, DD(X) Program Office, for transition into Advanced Gun System (AGS) Program upon successful completion of defined transition criteria

SPONSORS/PERFORMERS:

Performer	Name / Organization
Principal Investigators	Amir Chaboki / United Defense
	Rodney Hubbard / NSWC/DD
S&T Program Officer	Peter Morrison / ONR
351 Project Officer	Joe McPherson /

Advanced Gun Barrel Technologies

Objectives

- Identify & develop Gun Barrel Technologies that enable upgrades to existing barrel capabilities for Naval gun propulsion missions
  - *Increased Gun Barrel Erosion & Fatigue Life*
  - *Improved Gun Barrel Thermal and Ballistic Performance*
  - *Reduced Life Cycle Cost*

Payoffs

- Increased Gun System Availability
- Improved Ballistic Capability (Higher KE for increased range)
- Lower Life Cycle Cost

Technologies

- Refractory Barrel Materials / Coatings
- Composite Materials & Manufacturing Technology
- Advanced Integrated Barrel Design

Transition Criteria

1 - Compliance with AGS Interface Control Docume

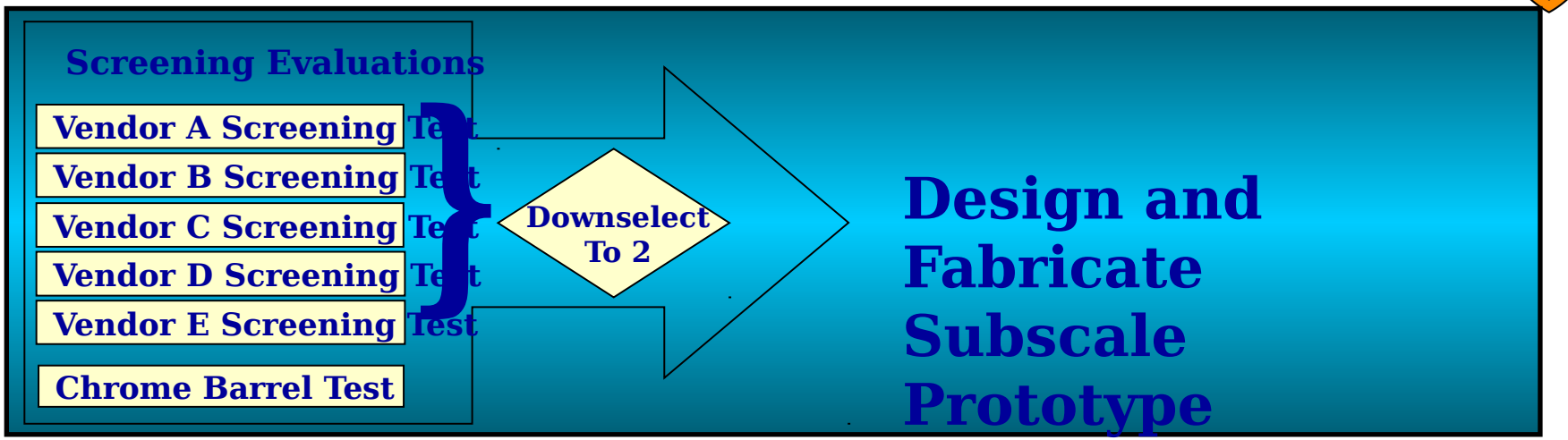
2 - Equivalent Ballistic Performance to Baseline AG

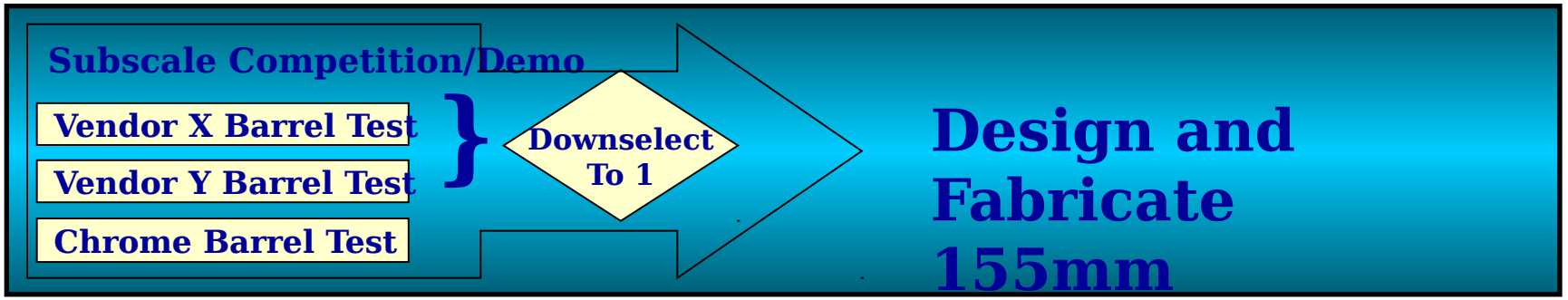
3 - 50% Improvement in Barrel Life Over Baseline A

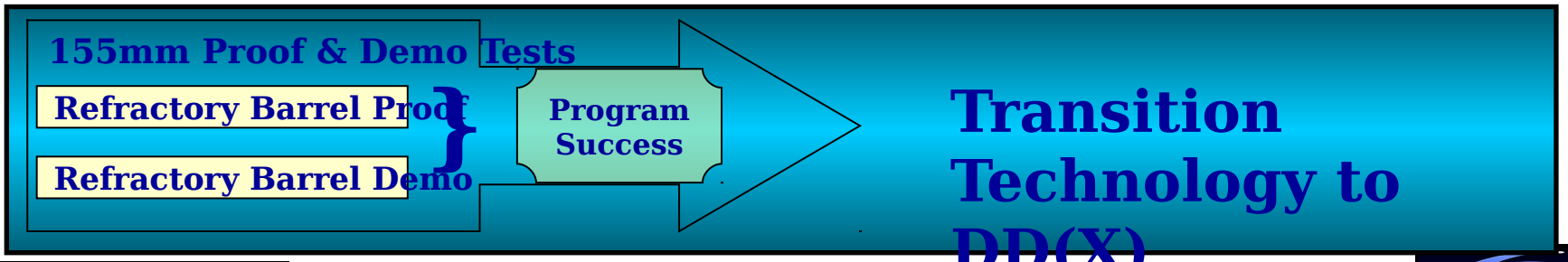
4 - Reduced Life Cycle Cost Compared to Baseline A

5 - Production and Gun Fire Testing of Full-scale Pr

Technical Approach

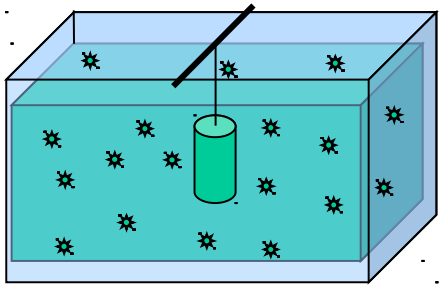






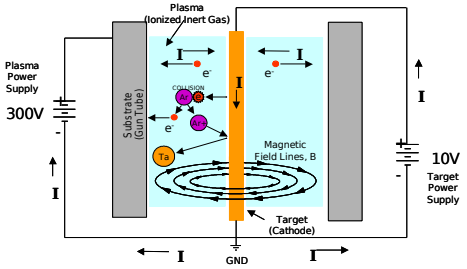
Candidate Coating Technologies

Electroless Nickel-Boron



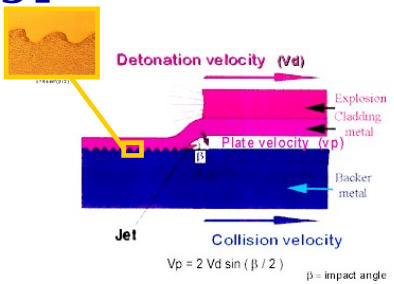
Catalytic plating process produces extremely uniform coating even on complex geometries

Cylindrical Magnetron Sputtering



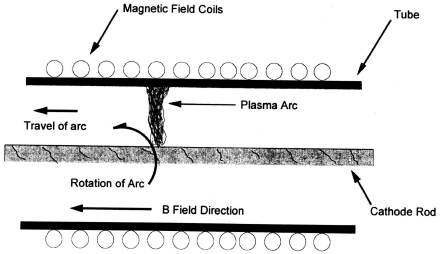
Material is sputtered, from a coaxial target, uniformly over the inside diameter of the barrel

Explosive Cladding



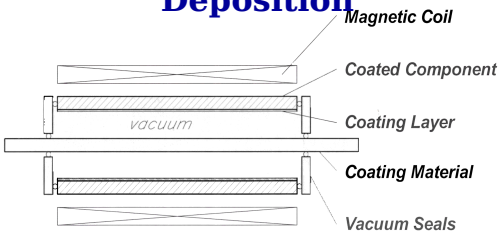
Tube of cladding material is mechanically bonded with the gun barrel in a collision driven by an explosive detonation

Coaxial Energetic Deposition



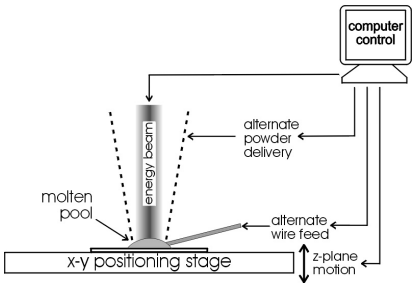
Plasma arc rotates around center conductor and travels along its length depositing material

Electromagnetically Enhanced Physical Vapor Deposition



Electrically controlled magnetic fields enhance the plasma environment of the physical vapor

Solid Free Form Fabrication



Engineered material is created by alloying of powdered and/or wire-fed metals

Test Approach

- Tests must maintain traceability to the objective AGS environment
- Parameters of the objective environment to be matched
  - Thermal profile through coating and near bore
    - Best match of temperature effects and thermal stress
  - Chemical environment of propellant with bore
    - Best match of chemical attack on bore surface
  - Mechanical stresses
    - Best match of stresses in coating and at interface

Screening Test Fixture

- Objective
  - Provide similar thermal, chemical and mechanical conditions to AGS barrel with reasonable cost
- Approach
  - Design a new gun fixture using interior ballistics analysis to drive the configuration through the predicted thermal response rather than conventional parameters such as muzzle velocity and chamber pressure

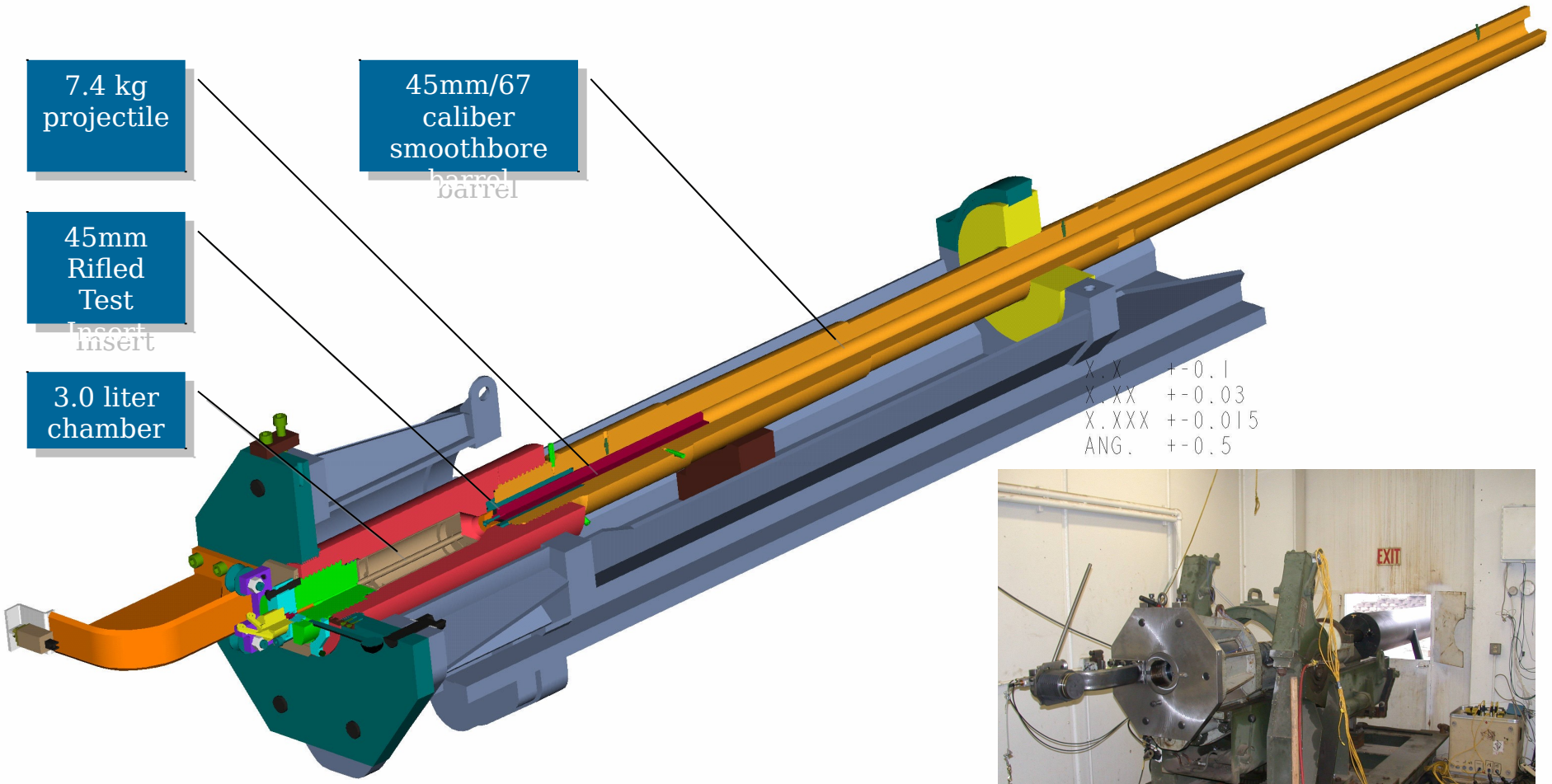
45mm Test Fixture

7.4 kg projectile

45mm/67 caliber smoothbore barrel

45mm Rifled Test Insert

3.0 liter chamber



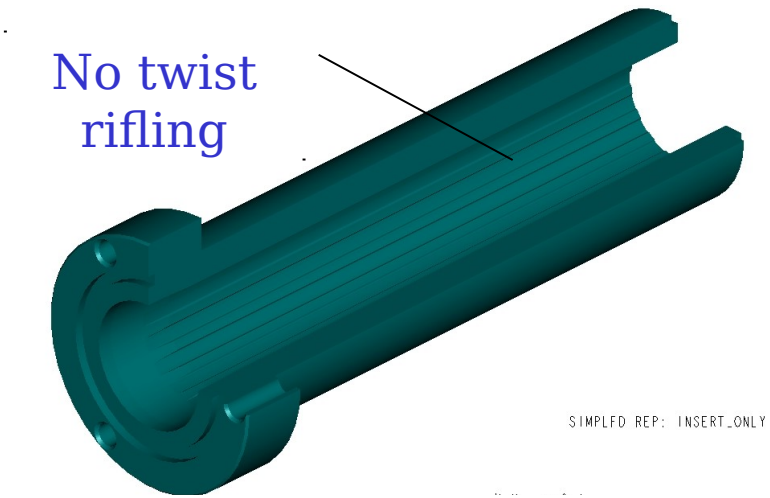
45mm gun in place at UDLP test ra

United Defense

NAVSEA DAHLGREN SURFACE WARFARE CENTER DIVISION

Test Insert

- Test insert used to evaluate the performance of advanced coating materials
- Insert includes shot start region and first few calibers of projectile travel
- Thickness sized to provide a strain level similar to the 155mm barrel at maximum service pressure conditions
- Insert does not simulate compressive residual stress from autofrettage in the large caliber barrel



M30A1 & Hybrid Equilibrium Analysis

M30A1

NC1258
NG
NQ
EC
KS
Ethanol
Graphite

Equilibrium Products
(with chrome)

N2
CO
H2O
CO2
H2
Cr2O3 (S) **0.73%**
KOH
H2S
NH3
COS

Equilibrium Products
(with Tantalum)

N2
CO
H2O
CO2
H2
Ta2O5 (S) **0.61%**
KOH
H2S
NH3
COS

Hybrid Propellant

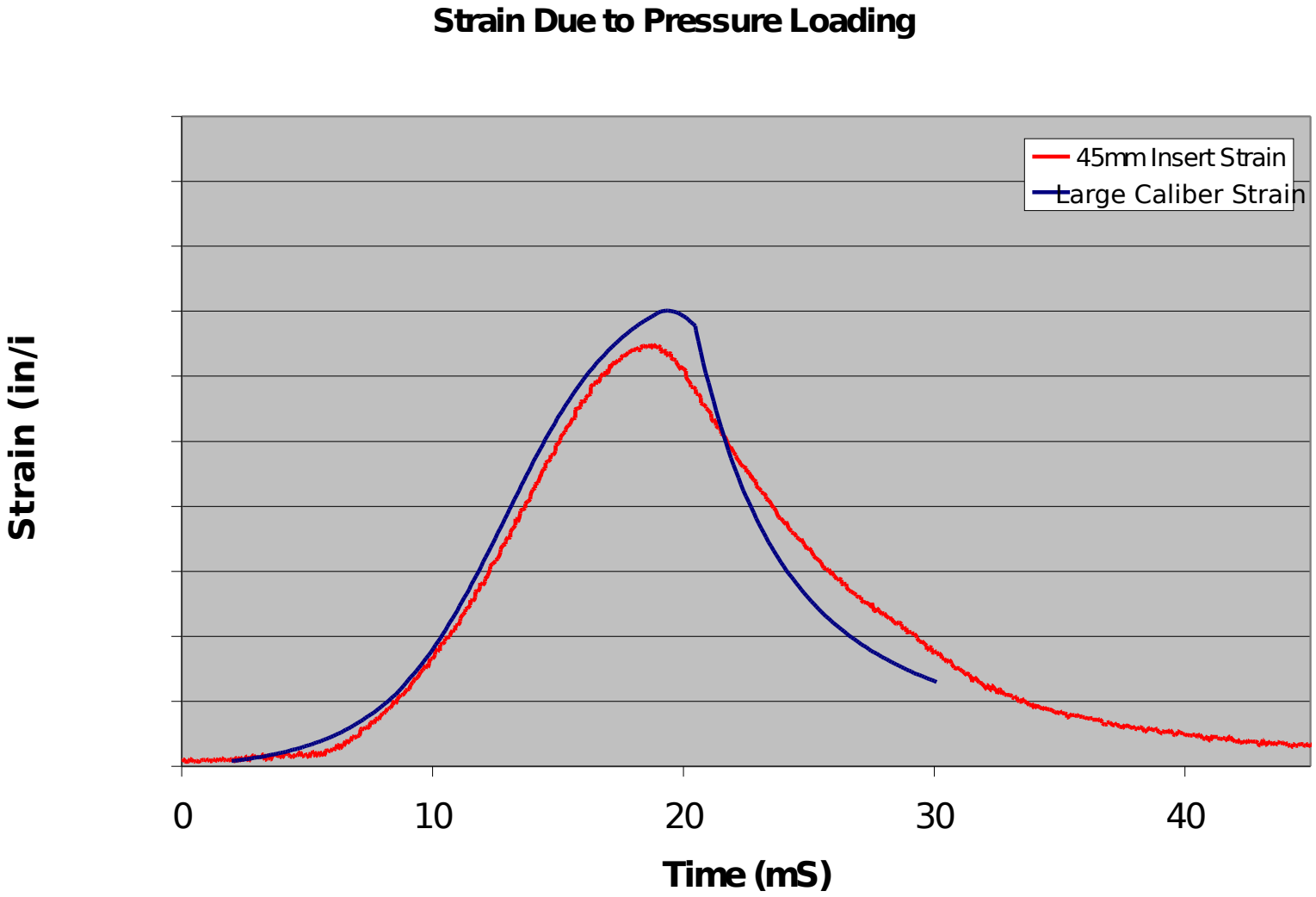
NC1280
NG
DBP
DPA
G59
H2O
Ethanol
C

CO
N2
CO2
H2O
H2
CH4
Cr2O3 (S) **0.73%**
NH3
HCN
C2H4

CO
N2
CO2
H2O
H2
CH4
Ta2O5 (L) **0.61%**
NH3
HCN
C2H4

When reacted in the presence of chrome or tantalum, the M30A1 and the hybrid propellant produce the same products, in the same quantities

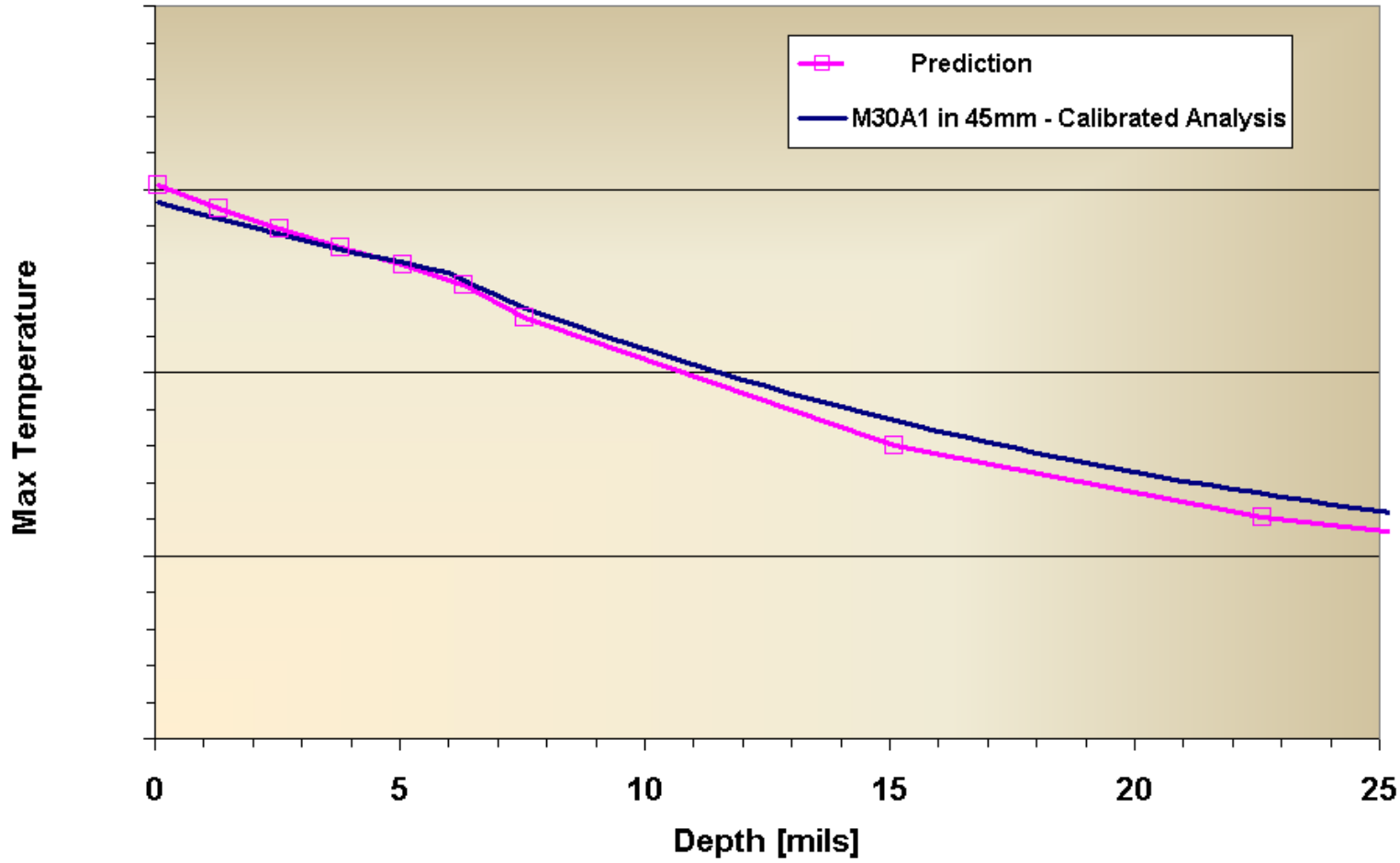
Strain Due to Firing Loads



Strain response to firing loads is a good match with predicted behavior

Thermal Results

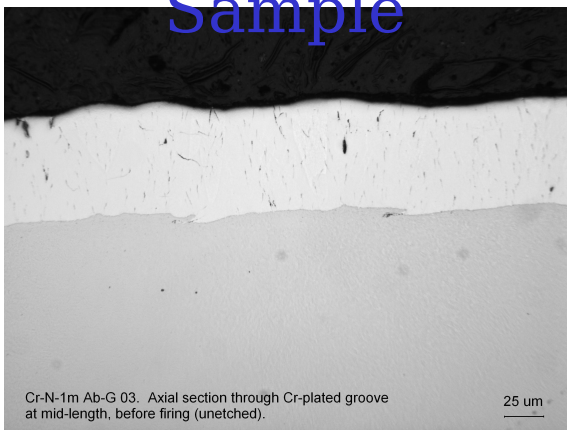
Maximum Temperature Near Bore

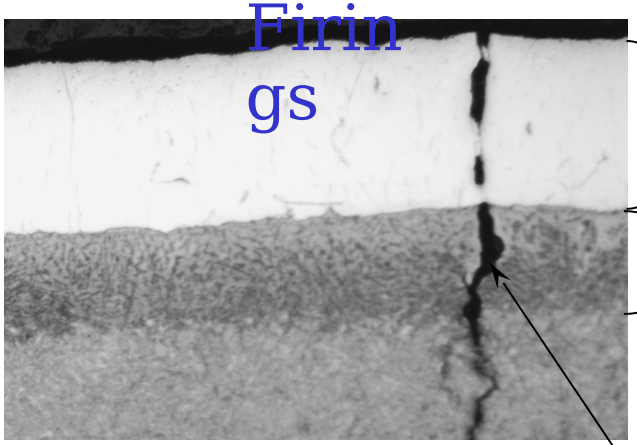


Chrome Plated Baseline Evaluation

Unfired Sample

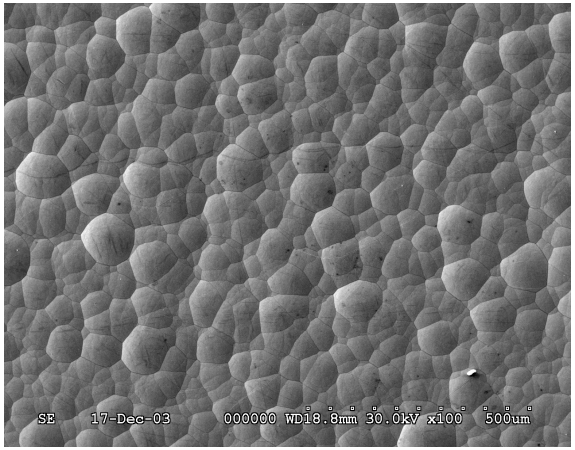
57 Firings

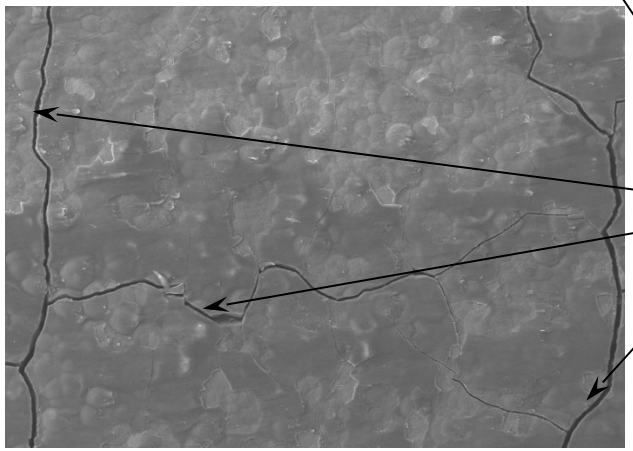




Chrome Plating

Heat Affected Zone





Heat Check Cracks

Current Status

- Screening evaluation testing is complete
  - Performed 50 shot test series on chrome plated sample for baseline
  - 50 shots each on six different technologies
  - Materials analysis of test samples is in process
- Source selection process for 76mm barrel development underway
  - Selection will be based on performance in screening test, proposal evaluation and past performance on similar projects

Path Forward

- Select participants in 76mm development phase and award subcontracts
  - Over the next 18 months we will design and build prototype barrels for the Mk 75 76mm gun mount and test them in rapid fire mode
  - Effort will also include preliminary design work for 155mm barrel